Following are Peer Review Comments of

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Submitted to Mark Gowdy, California Regional Water Quality Control Board, Central Valley Region on May 12, 2004

Introduction

This document reviews the document "Control Program for Factors Contributing to the Dissolved Oxygen Impairment in the Stockton Deep Water Ship Channel" (DWSC). The authors of the control program faced a difficult challenge to devise a structured approach to address the dissolved oxygen (DO) depletion in the DWSC, particularly when considering the complexity of the processes that define the problem. As a summary, I feel that the authors have defined the problem appropriately, and have identified the factors responsible for the problem, including describing the complexity that results from the interaction of these factors. My concerns rest in the analysis of the loading capacity of the system, and particularly the allocation to the three primary loading factors. In the next section, I will discuss briefly some of the issues raised in the problem presentation; the more important discussion of the definition of the loading capacity and the allocation to the three primary factors will follow.

Problem Description

It seems that the primary data set to establish the magnitude and frequency of the DO depletion problem is the DWR monitoring station at the northern end of Rough & Ready Island. This data set provides an integrated measure of DO in the top 17 feet of the water column, at a single location along the axis of the DWSC. It is not clear from the presentation whether or not this measure of DO is the appropriate one for comparison with the water quality objective. In particular, the lower 17-18 feet of the water column (not sampled) could be important due to the likelihood of more frequent and larger magnitude DO depletion events. It would be useful to clarify the objective in this discussion (whether it is based on a depth-averaged concentration or not, for example).

I would also like to emphasize the point that the authors make regarding the shift of low DO concentrations downstream by high flows in the San Joaquin River (middle of p.22). The fact that much of the discussion – particularly figure 4.3 – is based on point measurements means that the effects of flow on the DO depletion problem in the DWSC as a whole is likely to be overstated. That is, high flows do not necessarily eliminate the DO depletion problem, but rather shifts the problem away from the monitoring location.

Finally, tidal dispersion in the system is not discussed. Energetic oscillatory tidal flows exchange waters between the DWSC and the adjoining waters both upstream and downstream with each tidal cycle (12.4 hours). At a minimum, the tidally-driven exchange of oxygenated water into and out of the DWSC will result in the dispersion of dissolved oxygen into the DWSC and is likely to be an important re-aeration mechanism.

Loading Capacity

The loading capacity formulation ($LC_T = [DO_{sat}-DO_{obj}]*Q_{DWSC}$) is essentially saying that the available oxygen is entirely determined by advection from the San Joaquin River

upstream, and neglects re-aeration. It should be noted that re-aeration is not limited to just vertical exchange with the atmosphere; tidal motions will disperse oxygenated waters into the DWSC from both upstream and downstream and for the purposes of this analysis could be considered as a re-aeration. Further, and perhaps more importantly, this formulation does not include any consideration of the rate of consumption of oxygen in the DWSC, or the residence time of waters in the DWSC. These factors are the ones that have been altered by changes in the geometry of the DWSC and the diversion of San Joaquin River flows. That fact that the DO concentration profiles follow a sag profile through the DWSC (end of section 4.1.1, p.22) indicates that these rates are significant and that re-aeration and depletion rates should be identified and acknowledged in the loading capacity. This will be discussed further in the next section.

Because the formulation of the loading capacity as presented neglects the re-aeration and depletion rates, it is quite difficult to evaluate whether the margin of safety is appropriate. Due to the neglect of re-aeration, and essentially assuming an infinite residence time (such that the oxygen demand is fully realized), the loading capacity as formulated is likely to be overly conservative.

Allocation to Primary Factors

I agree with the authors' determination that upstream loading, changes to the geometry of the DWSC and the reduction of San Joaquin River flows have all contributed to the depletion of DO in the region. The equal division of the calculated loading capacity into three equal parts, however, does not seem to be justified. The use of a linear decomposition between the three factors ignores the multiplicative effects that are inherent in the processes as described. As acknowledged in the discussion, the altered geometry would not be a problem if there were no loading from upstream. This is due to the fact that the dredging of the DWSC has magnified the rate of consumption of oxygen and increased the residence time in the DWSC so that the loading from upstream can have a more deleterious effect on the system. Linearly allocating the 'loading' to the three primary factors obscures these non-linear interactions.

As an alternative, the limit for loading from upstream could be calculated based on the sag profile that has been validated for the system. This solution would define the upstream loading capacity (LC) as a function of the volume of the DWSC, the net flow through the DWSC, and the rate of oxygen consumption in the DWSC. As such, this limit on the upstream loading would be determined by the geometry of the DWSC and the net flow through the DWSC, and the effects of re-aeration by tidal dispersion into the DWSC could be accounted for. To meet the requirements for DO in the DWSC, therefore, several strategies could be pursued: decreasing upstream loading, reducing the rate of oxygen depletion in the DWSC, providing additional oxygen supply (aeration), or a combination of these. Allocation of the financial responsibility to meet these requirements in equal parts between the parties responsible for the three primary factors would then be appropriate. Formulating the loading capacity in this way – such that the

limit is based on factors that are determined by the DWSC geometry and flow – will allow for strategies that trade-off mitigations upstream and within the DWSC.

Implementation Plan

In view of the scientific uncertainties described above, and due to the fact that research on the DWSC is currently being pursued and will be continued into the future, I would strongly encourage the pursuit of a phased approach.